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TA98-010
NEDUTR-7-00
February 2001



**EVALUATION OF SCUBAPRO
"SUPERHAWK" BUOYANCY
COMPENSATOR**

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<Unlimited>

<Distribution>

20010426 026

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY N/A		3. DISTRIBUTION/AVAILABILITY OF REPORT DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited		
2b. DECLASSIFICATION/DOWNGRADING AUTHORITY				
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NEDU Technical Report No. 7-00		5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION Navy Experimental Diving Unit	6b. OFFICE SYMBOL (If Applicable) 031	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and ZIP Code) 321 Bullfinch Road, Panama City, FL 32407-7015		7b. ADDRESS (City, State, and Zip Code)		
8a. NAME OF FUNDING SPONSORING ORGANIZATION Naval Sea Systems Command	8b. OFFICE SYMBOL (If Applicable) 00C	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code) 2531 Jefferson Davis Highway, Arlington, VA 22242-5160		10. SOURCE OF FUNDING NUMBERS		
		PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO. TA98-010
11. TITLE (Include Security Classification) EVALUATION OF SCUBAPRO "SUPERHAWK" BUOYANCY COMPENSATOR (UNCLASSIFIED)				
12. PERSONAL AUTHOR(S) C. J. Zaroni				
13a. TYPE OF REPORT Technical Report	13b. TIME COVERED FROM Dec 00 TO Jan 01	14. DATE OF REPORT (Year, Month, Day) February 2001	15. PAGE COUNT 7	
16. SUPPLEMENTARY NOTATION				
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) BC Testing		
FIELD	GROUP			SUB-GROUP
19. ABSTRACT: NEDU was tasked to conduct a survey of commercially available buoyancy compensators (BCs) and perform testing to determine which BC perform satisfactorily. Buoyancy compensator evaluation was conducted in three phases. Phase I included receipt inspection of the buoyancy compensator, technical review of the manufacturer-supplied documentation (instructions / repair manuals), diver orientation, and Test Pool Evaluation (surface floating attitudes if BCs were used as life jackets). No failure mode analysis was conducted. Phase II consisted of buoyancy / lift capacity testing in the OSF at 190 fsw. Phase III consisted of manned dives in the Gulf of Mexico to test diver buoyancy control and operational characteristics.				
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED X SAME AS RPT. DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION Unclassified		
22a. NAME OF RESPONSIBLE INDIVIDUAL NEDU Librarian	22b. TELEPHONE (Include Area Code) 850-230-3100	22c. OFFICE SYMBOL		

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INTRODUCTION

Navy Experimental Diving Unit (NEDU) is tasked¹ to conduct surveys of commercially available buoyancy compensators (BCs) and perform testing to determine which BCs perform satisfactorily in accordance with references (2) and (3). All buoyancy compensators that meet the above requirements will be candidates for recommendation to the Authorized for Navy Use (ANU) list. The purpose of this technical report is to determine if the ScubaPro "Superhawk" buoyancy compensator meets those requirements.

METHODS

GENERAL

Each BC was tested and evaluated in three different environments: Phase I, Bench Test; Phase II, Controlled Environment (Test Pool/Ocean Simulation Facility [OSF]); and Phase III, Open Ocean Diving. During bench testing, two qualified U.S. Navy divers evaluated each BC for completeness and adequacy of its maintenance manuals and technical documentation, skill levels that it required to perform routine repair and maintenance, and the operations of the integrated weight belt and all BC components. In a controlled environment each BC was tested and evaluated for buoyancy and lift capability. During open water dives each BC was used and evaluated by qualified U.S. Navy divers in both single and double SCUBA tank configurations to a minimum of 30 fsw (9.4 msw). The conversion for msw is in accordance with reference (3).

EXPERIMENTAL DESIGN AND ANALYSIS

All BCs tested were off-the-shelf items; three sizes were tested: medium, large, and X-large. The Task Leader or assigned representative was present during the setup and post-dive procedures for all BCs.

Phase I testing:

- Each model BC was evaluated by two qualified U.S. Navy divers for ease of operation and maintenance procedures.
- Average cost from five different suppliers was acquired.

Specific comments from evaluators were compiled and documented.

Phase II testing:

- All BCs of different sizes were tested to 190 fsw (59.4 msw) using the OSF. Each BC was fully inflated three times in both single and twin configurations, and the average lift capacity was recorded.

Phase III testing:

- All BCs of different sizes were evaluated during a series of open water dives conducted at a minimum depth of 30 fsw. Divers completed a human factor

questionnaire after each dive. A set of statistics describing the responses and specific comments were compiled.

EQUIPMENT AND INSTRUMENTATION

No special or proprietary tools were required to perform routine maintenance or repair on the BCs.

- a. Phase I: During bench testing the following equipment was used:
 - (1) Fully charged SCUBA bottle and an approved regulator
(used to supply low-pressure air to perform equipment checks)
 - (2) Manufacturer's instructions and maintenance manual
 - (3) Miscellaneous hand tools and adapter fittings
 - (4) Weights (soft or molded)
- b. Phase II: During OSF and open ocean testing the following equipment was used:
 - (1) Calibrated spring scale (Model #895, Viking Scale, Shubuta, MS), 0 to 50 pounds (0 to 22.68 kg)
 - (2) Lanyards, spinnaker shackles, and weight as appropriate to anchor the BCs to the deck in the wet chamber or on top of the bridge span
 - (3) Fully charged SCUBA bottle and an approved regulator (used to supply low-pressure air)
 - (4) Personnel as required
 - (5) Weights
- c. Phase III: During at-sea testing the following equipment was used:
 - (1) Fully charged SCUBA bottle, approved regulator, and all other personal diving equipment needed to perform a SCUBA dive
 - (2) Personnel as required
 - (3) At-sea diving platform

PROCEDURES

BC evaluation was conducted in three phases: (1) Receipt inspection and technical review of manufacturer-supplied documentation, (2) OSF wet chamber evaluation (buoyancy/lift capacity at 190 fsw), and (3) Open water dives to test buoyancy control and operational characteristics.

- a. Phase I testing began with a review of the following:
 - (1) Completeness and adequacy of the maintenance manuals and technical documentation
 - (2) Requirements for special or proprietary tools
 - (3) Skill levels required to perform routine repair and maintenance
 - (4) Operation of the integrated weight system
 - (5) Operation and activation of all BC components
 - (6) Ease of assembly from single tank configuration to twin tank configuration
 - (7) Unit price

A technical documentation and operational function worksheet was completed by each qualified diver, and returned to the Task Leader.

b. Phase II Testing: Buoyancy/lift capacities of the units were tested in the OSF wet chamber at a depth of 190 fsw. All divers participating in the study were required to familiarize themselves with the contents of the user's manual, including the location of controls on the BC and donning procedures.

A calibrated Viking Scale model #895 was attached to the deck grating of the OSF or shackled onto the top of a sunken bridge span to measure buoyancy. Each BC was attached to the scale and tested. The buoyancy was measured and documented; at a minimum, each BC was required to provide 10 lbs. of positive lift, as outlined in reference (2). Each BC was also tested for leaks at depth.

c. Phase III Testing: Manned open water dives were conducted to a minimum depth of 30 fsw to determine each BCs swim characteristics. Results were documented using a diver's questionnaire.

RESULTS

PHASE I

The documentation that the manufacturer supplied on the use and technical specifications of the BC, the exploded views/diagrams of it, and the service and parts for it was unsatisfactory. No parts list or technical specifications were included within the supplied buoyancy compensator manual, but these documents were available from the manufacturer upon request. There are requirements for special proprietary tools for major adjustments of the waist band, and a special banding kit is necessary for installing and removing of twin tanks. Skill levels required to perform routine maintenance should be those of at least a Second-Class Diver. The weights of the integrated weight system were secure, and it was easy to operate the release mechanism and reinstall them for redeployment. All BC components were easy to operate and activate. There were minor difficulties assembling the single tank configuration to the twin tank configuration.

The manufacturer's suggested cost per unit (Medium – X-Large) is \$385.

PHASE II

All three sizes of the "Superhawk" in the single tank configuration averaged 35.2 lbf of positive lift at 190 fsw (see Table 1).

The measured buoyancy of the "Superhawk" BC was approximately 40.5% less than the 46 lbf quoted by the manufacturer for all bladder sizes. However, that difference might be attributed to differing test conditions, procedures, or depths.

In the twin tank configuration the three sizes of the "Superhawk" averaged 37 lbf of positive lift at 190 fsw (see Table 1).

The measured buoyancy of the "Superhawk" BC was approximately 41.3% less than the 46 lbf quoted by the manufacturer for all bladder sizes. This difference might be attributed to differing test conditions, procedures, or depths.

PHASE III

During the manned evaluation of the ScubaPro "Superhawk," 13 divers tested the buoyancy compensator in both tank configurations to depths ranging from 30 to 130 fsw. The BC scored ratings of 5.02 in the single tank configuration and 5.22 in the twin tank configuration on a scale of 1 – 6, with 4.0 being the minimum mark for an overall acceptable score.

CONCLUSIONS

During testing, two major items of note were encountered. First, in accordance with the manufacturer's technical manual the cylinder band strap must be wet prior to installation of the single configuration tank. If this was not done, the bottle tended to slip down and out of the BC, and this could cause the diver's air supply to be lost.

The second item noted was the difficulty shifting the BC from single tank configuration to twin tank configuration. In order to install the twin tank configuration, tools and a special banding kit are needed. Once the BC is in the twin tank configuration, tools are required to remove the tanks from the BC for charging with air or for any other necessary maintenance.

The buoyancy compensator "Superhawk" has an integrated weight belt system that the diver can remove and ditch from the buoyancy compensator in case of emergency⁴. Either side or both sides of the system can be ditched to regain proper buoyancy control. We suggest that only one side be dumped at a time, to allow the diver to see if proper buoyancy can be regained. If not, the other side may be ditched. This system is easy to use and easy to reinstall onto the buoyancy compensator. The weight module pockets are designed to hold a maximum of 16 lbs. of molded or soft weights in each pocket for a total onboard weight capacity of 32 lbs.

RECOMMENDATIONS

Based on the testing and evaluation in accordance with reference (3) and reported in Tables (1) and (2), the ScubaPro "Superhawk" (P/N: Medium 22.121.301 M, Large 22.121.401 L, and Extra Large 22.121.501 XL) is recommended for continued use. No surface floating attitude testing was conducted; therefore, we do not recommend that this buoyancy compensator be used as a life preserver.

**Table 1. ScubaPro "Superhawk" Buoyancy Compensator
Pull Test Data in Single and Twin Tank Configuration**

ScubaPro "Superhawk" Single Tank Configuration					
NO.	NOMENCLATURE	BC #	PULL TEST WEIGHT (LBF)	DEPTH	INFLATION METHOD
1	ScubaPro "Superhawk"	M	35.2 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
2	ScubaPro "Superhawk"	L	35.2 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
3	ScubaPro "Superhawk"	XL	35.2 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
ScubaPro "Superhawk" Double Tank Configuration					
NO.	NOMENCLATURE	BC #	PULL TEST WEIGHT (LBF)	DEPTH	INFLATION METHOD
1	ScubaPro "Superhawk"	M	37 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
2	ScubaPro "Superhawk"	LG	37 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
3	ScubaPro "Superhawk"	XL	37 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE

Table 1. Each size BC was tested to 190 fsw (59.4 msw) using the OSF. Each BC was fully inflated three times in both single and twin configurations and the average lift capacity was recorded.

**Table 2. Human Factors Evaluation of the ScubaPro "Superhawk"
Buoyancy Compensator in Single and Twin Tank Configuration**

ScubaPro "Superhawk" Single Tank Configuration											
QUESTIONNAIRE #	#8 COMFORT	#9 MOBILITY	#10 DONNING & DOFFING	#11 NEUTRAL BUOYANCY	#12 LOCATION OF CONTROLS	#13 OPERATING CONTROLS	#14 WATER DRAG	#15 COMFORTABLE DIVING	#16 OVERALL RATING	AVERAGE	
1	6	6	6	6	6	6	5	6	6	5.89	
2	5	5	5	5	5	5	4	5	5	4.89	
3	6	6	6	6	6	6	5	5	5	5.67	
4	5	5	5	5	5	5	5	5	5	5.00	
5	5	1	5	5	5	5	5	6	5	4.67	
6	5	6	6	5	4	5	5	6	5	5.22	
7	6	5	6	5	6	6	5	6	6	5.67	
8	6	6	5	5	4	5	4	5	5	5.00	
QUESTION AVERAGE	5.50	5.00	5.50	5.25	5.13	5.38	4.75	5.50	5.25	5.25	
OVERALL AVERAGE										5.25	
ScubaPro "Superhawk" Twin Tank Configuration											
QUESTIONNAIRE #	#8 COMFORT	#9 MOBILITY	#10 DONNING & DOFFING	#11 NEUTRAL BUOYANCY	#12 LOCATION OF CONTROLS	#13 OPERATING CONTROLS	#14 WATER DRAG	#15 COMFORTABLE DIVING	#16 OVERALL RATING	AVERAGE	
1	5	6	6	6	4	4	6	6	5	5.33	
2	5	5	5	6	5	4	5	6	5	5.11	
3	6	6	6	5	5	4	6	6	5	5.44	
4	5	5	5	6	5	4	5	6	5	5.11	
5	4	4	5	4	4	4	4	4	4	4.11	
QUESTION AVERAGE	5.00	5.20	5.40	5.40	4.60	4.00	5.20	5.60	4.80	5.02	
OVERALL AVERAGE										5.02	

Table 2. A series of evaluation dives completed per BC, per tank configuration. All open water dives were conducted to a minimum depth of 30 fsw (9.4 msw). Divers completed a human factors questionnaire after each dive. A set of statistics describing the responses and specific comments were compiled. The BCs were scored on a 1 – 6 scale with 4.0 being the minimum mark for an overall acceptable score (1 = poor, 4 = adequate, 6 = excellent).

REFERENCES

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